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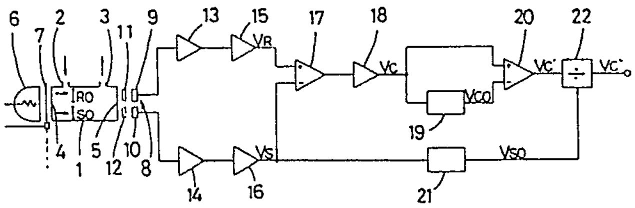
(54) Infrared analyzer.

(57) In an infrared analyzer of the disclosure a gas having no absorption at the characteristic absorption wavelength of a specified ingredient gas is introduced into a cell (1) to determine a zero gas measuring signal (V_{SO}) and a zero gas comparative signal (V_{RO}). A differential signal (V_{CO}) obtained by amplifying a difference between said both signal and said zero gas measuring signal a memorized to subtract said differential signal (V_{CO}) from a differential signal obtained by amplifying the difference between a comparative signal and a measuring signal when a sample gas is measured. The subtraction signal V_C' received at this time is divided by said zero gas measuring signal (V_{SO}), whereby a concentration of said specified ingredient gas is determined. According to the invention it is not necessary to introduce expensive span gas into the cell when conducting a span calibration so that not only the span calibration can be simple and inexpensively conducted but also the zero calibration and the span calibration can be carried out simultaneously and in a short time.

Fig.1



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INFRARED ANALYZER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an infrared analyzer as claimed in the precharacterizing portion of claim 1.

Description of the Prior Art

It is in general required for an infrared analyzer to conduct a zero calibration and a span calibration periodically. In said analyzer infrared rays from a light source are passed through a cell, into which a sample gas is introduced. A difference bet ween a signal (measuring signal) proportional to an energy of an infrared ray having a characteristic absorption wavelength of the specified ingredient gas obtained at that time and a signal (comparative signal) proportional to an energy of an infrared ray having a wavelength showing no absorption or a negligible absorption by said specified ingredient gas is amplified to determine a concentration of said specified ingredient gas from a quantity of the infrared ray having said characteristic absorption wavelength absorbed.

In order to conduct the zero calibration and the span calibration in the above described infrared analyzer, the zero gas is introduced into the cell and after stabilisation of the indication a zero-point regulation is carried out. Then the span gas is introduced into the cell and alter stabilisation of the indication a span regulation is conducted.

However, since a span gas of high approval accuracy must be used at every span regulation in such a gas calibration method, the calibration costs are expensive.

On the contrary, it is possible to employ the so-called mechanical calibration, in which the intensity of the light passing through the cell is reduced by means of a metallic plate and a filter in order to change a quantity of a light incident upon a detector. In this way the calibration is conducted without using a gas.

However, in this mechanical calibration, in the case where the metallic plate is used to reduce the intensity of the light passing through the cell, if its insert position is dislocated, the sensitivity is subtly influenced and an error may be produced. In addition, in the case where the filter is used to reduce the intensity of the light passing through the cell, the filter itself may for example be stained and damaged which leads to a change in the quantity of the light. As above described, the mechanical calibration exhibits disadvantages in that it is difficult to keep the superior accuracy and troubles are apt to occur due to the existence of movable parts.

In order to solve the disadvantages of the above described gas calibration and mechanical calibration, for example Japanese Patent Application Laid-Open No. Sho 61-20840 has disclosed a method in which when a zero is gas is measured, an input signal is changed to the same extent as in the case of an absorption by a gas and further an amplifying factor is changed so that said change may amount to an appointed value to conduct the span calibration.

However, according to this publication, the span regulation must be conducted after the zero-point regulation and thus the zero calibration and the span calibrati on can not be conducted simultaneously and in a short time.

SUMMARY OF THE INVENTION

The present invention has been achieved in view of the above described disadvantages and it is an object of the present invention to provide an infrared analyzer capable of not only conducting the zero calibration and the span calibration in high accuracy without using an expensive gas but also conducting these calibrations simultaneously and in a short time.

In order to achieve the above described object, according to the infrared analyzer of the present invention, a gas having no absorption at the characteristic absorption wavelength of the specified ingredient gas is introduced into a cell to determine a zero gas measuring signal and a zero gas comparative signal. A differential signal obtained by amplifying a difference between said both signals and said zero gas measuring signal are memorized to subtract said differential signal from a differential signal obtained by ampliying a difference between a comparative signal and a measured signal when a sample gas is measured. The subtraction signal received at this time is divided by said zero gas measuring signal, whereby a concentration of said specified ingredient gas is determined.

With the above described construction, since the zero gas measuring signal obtained when the zero gas is measured is memorized and the calculation is conducted on the basis of this memorized zero gas measuring signal, the span calibration does not require the introduction of the expensive span gas into the cell, whereby not only the span calibration can be simply and inexpensively conducted but also the zero calibration and the span calibration can be conducted simultaneously and in a short time.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing an infrared analyzer according to one preferred embodiment of the present invention;

Fig. 2 is a diagram showing principal parts of an infrared analyzer according to another preferred embodiment of the present invention; and

Fig.3 is a diagram showing principal parts of an infrared analyzer according to a further preferred embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention are below described with reference to the drawings.

Fig. 1 shows a rough construction of a so-called one light source-one cell type infrared analyzer. Referring to Fig. 1, reference numeral 1 designates a cell provided with an inlet port 2 for a sample gas, an outlet port 3 for the sample gas and cell windows 4,5 permeable to infrared rays formed at both ends portions thereof. Reference numeral 6 designates a light source provided outside of one cell window 4 of said cell 1 for radiating infrared rays so that the infrared rays radiated from said light source 6 may pass through the cell 1 to be incident upon a detector portion 8 which will be mentioned later. Reference numeral 7 designates a modulation chopper provided between the cell 1 and the light source 6 so as to be driven by a driving mechanism (not shown).

Reference numeral 8 designates a detector portion comprismg a comparative wavelength detector 9 and a measuring wavelength detector 10 arranged in parallel to each other and provided outside of the other cell window 5 of the cell 1, said measuring wavelength detector 10 being provided with a band pass filter 12 permeable to infrared rays having a characteristic absorption wavelength absorbed by a specified ingredient gas to be measured in the sample gas to put out a signal proportional to an energy of the infrared rays transmitted. In addition, said comparative wavelength detector 9 is provided with a band pass filter 11 transmitting infrared rays having a wavelength showing no absorption or merely a negligible absorption by said specified ingredient gas to put out a signal proportional to an energy of the infrared rays transmitted. Reference numerals 13, 14 designate preamplifiers provided on the output side of the comparative wavelength detector 9 and the measuring wavelength detector 10, respectively.

Reference numeral 15 designates a comparative signal amplifier provided at the output of the preamplifier 13 for amplifying a measured signal obtained from the comparative wavelength detector 9 through the preamplifier 13 at an appointed gain. Further, a comparative signal V_R which is an output from said comparative signal amplifier 15, being supplied to a (+) input terminal of a subtracter 17. Reference numeral 16 designates a measuring amplifier provided at the output of the preamplifier 14 for amplifying a measured signal obtained from the measuring wavelength detector 10 through the preamplifier 14 at an appointed gain. Further, a measuring signal V_S, which is an output from said measuring signal amplifier 16, being supplied to a (-) input terminal of said subtracter 17. Reference numeral 18 designates an amplifier provided at the output side of the subtracter 17 and V_C designates an output from said amplifier 17.

When measuring the concentration of a sample gas, upon introducing the sample gas into the cell 1 to apply the infrared rays from the light source 6 to said sample gas during modulation by means of the chopper 7, the infrared rays having the characteristic absorption wavelength absorbed by the specified ingredient gas to be measured in the sample gas are incident upon the measuring wavelength detector 10 while the infrared rays having the wavelength showing no absorption or merely a negligible absorption by said specified ingredient gas are incident upon the comparative wavelength detector 9. The respective signals supplied from these detectors 10, 9 are amplified by means of the measuring signal amplifier 16 and the comparative signal amplifier 15, respectively, to obtain the measuring signal V_S and the comparative signal V_R. The measuring signal VS is subtracted from the comparative signal V_R by the subtracter 17 and an output from the subtracter 17 is amplified by the amplifier 18 to obtain the differential signal V_C as concentration signal.

Reference numeral 19 designates a signal memory, such as a hold amplifier, for memorizing a value in the measurement of the zero gas when the zero gas is introduced into the cell 1 to apply the infrared rays to the zero gas. Reference numeral 20 designates a subtracter for producing a difference between said concentration signal V_C and a differential signal V_{CO} memorized in the signal memory 19. Said differential signal V_{CO} is obtained by multiplying a difference between a comparative signal (zero gas comparative signal) V_{RO} and a measuring signal (zero gas measuring signal) V_{SO} in the measurement of the zero gas by a gain G_C of the amplifier 18. Therefore, subtracter 20 supplies a subtraction output V_C' corrected with respect to the drift of the zero point.

Reference numeral 21 designates a signal memory, such as a hold amplifier, for memorizing said zero gas measuring signal V_{SO}. Reference numeral 22 designates a divider for dividing said subtraction output V_C' by said zero gas measuring signal V_{SO}. The resulting division output V_C'' is a signal proportional to merely the absorption of infrared rays by the specified ingredient gas, as below described.

That is to say, since said zero gas measuring signal V_{SO} is the measured signal in the measurement of the zero gas, it is dependent upon the light quantity of the light source 6, the stain of the cell windows 4, 5, the detection sensitivity of the detectors 9, 10, the change in the amplifying factor of the amplifier 16 and the like. On the other hand, the subtraction output V_C', which is an output after the correction of the zero drift, is influenced by the light quantity of the light source 6, the stain of the cell windows 4, 5, the detection sensitivity of the detectors 9, 10, the change in the amplifying factor of the amplifier 16 and the like in addition to the absorption of infrared rays by the specified ingredient gas. Accordingly, the division output V_C'' obtained by dividing the subtraction output V_C' by the zero gas measuring signal V_{SO} in said divider 22 becomes a signal proportional to merely the absorption of infrared rays by the specified ingredient gas because the influences by the light quantity of the light source 6, the stain of the cell windows 4, 5, the detection sensivity of the detectors 9, 10, the change in the amplifying factor of the amplifier 16 and the like common to the subtraction output V_C' and the zero gas measuring signal V_{SO} are compensated. In short, a signal, which has been corrected in both zero drift and span drift, can be obtained.

Next, the above described matter, in short the fact that the zero calibration and the span calibration can be conducted by the present invention, is described by the use of mathematical expressions.

Referring to Fig. 1, provided that the energy of the infrared ray having the comparative wavelength radiated from the light source 6 is I_{RO}, the energy of the infrared rays having the measuring wavelength radiated from the light source 6 being I_{SO}, the transmissivity of the cell 1 being T_C, the absorption of the infrared rays by the specified ingredient gas in the sample gas (hereinafter referred to as the infrared absorption) being x ($0 \leqq x \leqq 1$, as for the zero gas, $x = 0$), the energy (intensity) of the infrared rays reaching the comparative wavelength detector 9 being I_S, and the energy (intensity) of the infrared rays reaching the measuring wavelength detyector 10 being I_R, these I_S and I_R are expressed by the following expression (1), (2), respectively.

$I_R = I_{RO} \cdot T_C$ (1)

$I_S = I_{SO} \cdot (1-x) \cdot T_C$ (2)

Provided that the sensitivity of the comparative wavelength detector 9 is α_R, the total gain from the preamplifier 13 to the amplifier 15 being G_R, the sensitivity of the measurmg wavelength detector 10 being α_S, and the total gain from the preamplifier 14 to the amplifier 16 being G_S, the compartive signal V_R and the measured signal V_S are expressed by the following expression (3) and (4), respectively

$V_R = I_R \cdot \alpha_R \cdot G_R = I_{RO} \cdot T_C \cdot \alpha_R \cdot G_R$ (3)

$V_S = I_S \cdot \alpha_S \cdot G_S = I_{SO} \cdot (1-x) \cdot T_C \cdot \alpha_S \cdot G_S$ (4)

And, provided that the gain of the pmplifier 18 is G_C, the concentration signal V_C, which is the output of the amplifier 18, is expressed by the following expression (5):

$V_C = G_C \cdot (V_R - V_S) = G_C \cdot T_C \cdot \{I_{RO} \cdot \alpha_R \cdot \alpha\mu\rho - G_R - I_{SO} \cdot (1-x) \cdot \alpha_S \cdot G_S$ (5)

On the other hand, provided that the zero gas comparative signal is V_{RO} and the zero gas measuring signal is V_{SO} when the zero gas ($x = 0$) showing no absorption at the characteristic absorption wavelength of the specified ingredient gas is intoduced into the cell 1, the following expressions (6), (7) hold:

$V_{RO} = I_{RO} \cdot T_C \cdot \alpha_R \cdot G_R = V_R$ (6)

$V_{SO} = I_{SO} \cdot T_C \cdot \alpha_S \cdot G_S$ (7)

In addition, the differential signal V_{CO}, which is the output of the amplifier 18 at this time, is expressed by the following expression(8):

$V_{CO} = G_C \cdot (V_{RO} - V_{SO})$ (8)

This differential signal V_{CO} is memorized by the signal memory 19 and supplied to the subtracter 20.

Accordingly, the subtraction output V_C' expressed by the following expression (9) is supplied from the subtracter 20. Since $V_C = V_{CO}$ holds good during the measurement of the zero gas, $V_C' = 0$ holds good and thus the output, which has been subjected to the zero calibration, is obtained.

$V_C' = V_C - V_{CO}$ (9)

And, the subtraction output V_C' during the measurement of the sample gas is expressed by the following expression (10) from the above described expressions (5), (6), (7), (8), (9).

$V_C' = G_C \cdot T_C \cdot I_{SO} \cdot \alpha_S \cdot x \cdot G_S$ (10)

As understood from this expression, said subtraction output V_C' is proportional to the absorption of infrared rays x, the light quantity of the light source I_{SO}, the transmissivity T_C due to the stain of the cell windows 4, 5 and the like.

However, since the signal memory 21 memorizes the zero gas measuring signal V_{SO} during the measurement of the zero gas and supplies it to the divider 22, the division output V_C'' of the divider 22 is expressed by the following expression (11):

$V_C'' = V_C'/V_{SO}$ (10)

And, the following expression (12) is obtained from this expression (11) and the above described expressions (7), (10).

$V_C'' = (G_C \cdot T_C \cdot I_{SO} \cdot \alpha_S \cdot x \cdot G_S)/(I_{SO} \cdot T_C \cdot \alpha \mu \rho - \alpha_S \cdot G_C)-$
$= G_C \cdot x$(12)

Accordingly, an output proportional to the absorption x of the infrared rays can be obtained. In short, a signal, from which all factors, such as the light quantity of the light source (6), the stain of the cell windows 4, 5 and the sensitivity of the detectors 9, 10, influencing upon the detection sensitivity of the infrared analyzer have been eliminated, is obtained. This is the output, which has been subjected to the span calibration.

In addition, the relation between the absorption x of the rays and the concentration of the specified ingredient gas can be easily obtained from the output V_C' when the span gas having the known concentration is mad. Furthermore, it is sufficient that the gain G_C of the amplifier 18 is regulated so that the appointed output may be obtained.

The present invention is not limited by the above described preferred embodiment but various kinds of modification are possible.

For example, the signal treatment in the lower ranges of the detector 9, 10 in Fig. 1 may be conducted by a computer.

Fig. 2 is a block diagram showing the case where the signal treatment in the lower ranges of the amplifier 18 in Fig. 1 is conducted by a micro computer. Same reference numerals as in Fig. 1 designate the same parts as in Fig. 1 or the parts corresponding to those in Fig. 1.

Referring to Fig. 2, a measuring signal V_S, which is an output of the measuring signal amplifier 16, and a concentration signal V_C obtained by amplifying a difference between a comparative signal V_R, which is an output of a comparative signal amplifier 15, and the measuring signal V_S in an amplifier 18 are supplied to an A-D converter 24 through an input changeover device 23 to be converted into digital signals. The respective converted signals are taken into a micro computer 25. In addition, the micro computer 25 memorizes a zero gas measuring signal V_{SO} in the measurement of the zero gas and a signal V_{CO} by means of an internal memory to carry out said expressions (9), (11) according to an appointed program, whereby conducting the same treatment as in the infrared analyzer having the construction shown in Fig. 1. In addition, reference numeral 26 designates a display for displaying the calculated result.

Although the so-called one light source-one cell type infrared analyzer is shown in the above described respective preferred embodiments, the present invention is not limited to this type of infrared analyzer. For example, the present invention can be applied not only to an infrared analyzer, in which a reference cell is disposed in parallel to a sample cell, but also to a multi-component infrared analyzer for analyzing a plurality of components at the same time. In short, the present in vention can be applied to every infrared analyzer of the type in which a comparative signal V_R and a measured signal V_S are separately taken out and a difference between said both signals is generated as a concentration signal V_C.

Fig. 3 shows a preferred embodiment in which the present invention is applied to a multi-component analyzer. Referring to Fig. 3 reference numerals 16A, 16B, 16C --- designate measuring signal amplifiers for amplifying outputs of a plurality of measuring wavelength detectors (not shown) corresponding to a plurality of gaseous ingredients to be measured to put out measuring signals V_{S1}, V_{S2}, V_{S3}, --- respectively, reference numerals 17A, 17B, 17C --- designate subtracters provided so as to correspond to, the gaseous ingredients to be measured, respectively, and rereference numerals 18A, 18B, 18C --- designate amplifiers for amplifying differential signals between a comparative signal V_R and the outputs of said measuring signal amplifiers 16A, 16B, 16C --- to put out concentration signals V_{C1}, V_{C2}, V_{C3} ---, respectively.

Said concentration signals V_{C1}, V_{C2}, V_{C3} --- are supplied to a micro computer 25 through an A-D converter 24 and an input changeover device 23. In addition, in this preferred embodiment, the comparative signal V_R is supplied to the micro computer 25 through the A-D converter 24 and the input changeover device 23 in place of the measuring signal V_S. This leads to the reduction of the number of input channels of the input changeover device 23.

Measuring signals V_{S10},V_{S20},V_{S30}--- corresponding to the respective gaseous ingredients to be measured can be determined by said expression (8) on the basis of a comparative signal V_{RO} in the measurement of the zero gas and output V_{C10}, V_{C20},V_{C30}--- obtained by amplifying differences in the measurement of the zero gas.

That is to say,

$V_{S10} = V_{RO} - V_{C10}/G_C$ (13)
$V_{S20} = V_{RO} - V_{C20}/G_C$ (14)
$V_{S30} = V_{RO} - V_{C30}/G_C$ (15)

Accordingly, the same effect as in the above described respective preferred embodiments can be obtained by memorizing V_{S10}, V_{S20}, V_{S30} --- and V_{C10}, V_{C20}, V_{C30} --- in a memory within the micro computer 25 and carrying out the calculations by the above described expressions (9), (10) for every gaseous ingredient to be measured.

[Effects of the Invention]

As above described, according to the present invention, the signal in the measurement of the zero gas is memorized and the calculation is carried out on the basis of the memorized signal, so that it is not required to introduce the expansive span gas into the cell when the span calibration is conducted, whereby not only the span calibration can be simply and inexpensively conducted but also the zero calibration and the span calibration can be conducted simultaneously and in a short time.

Claims

1. An infrared analyzer, in which infrared rays from a light source (6) are runmng through a cell (1), into which a sample gas has been introduced, and in which a difference between a signal (measuring signal) proportional to an energy of the infrared rays having a characteristic absorption wavelength of a specified ingredient gas obtained at that time and a signal (comparative signal) proportional to an energy of the infrared rays wavelengths exhibiting no absorption or merely a negligible absorprion by said specified ingredient gas is amplified to determine a concentration of said specified ingredient gas from a quantity of the infrared rays having said characterictic absorption wavelength absorbed,

characterized in that

- a gas exhibiting no absorption at said characteristic absorption wavelength is introduced into said cell (1) to obtain a zero gas measuring signal (V_{SO}) and a zero gas comparative signal (V_{RO}),
- a first differential signal (V_{CO}) obtained by amplifying a difference between said both signals (V_{RO}, V_{SO}) and said zero gas measuring signal (V_{SO}) being memorized,
- said first differential signal (V_{CO}) being subtracted from a second differential signal abtained by amplifying a difference between a comparative signal (V_R) and a measuring signal (V_S) obtained in the measurement of the sample gas, and
- the resulting subtraction output (V_C') being divided by said zero gas measuring signal (V_{SO}) to determine a concentration of said specified ingredient gas.

2. The infrared analyzer as claimed in claim 1, **characterized in that** a memory (19) for storing the first differential (V_{CO}) is provided between an output of a first subtracter (17) for generating said differential (V_{CO}) and an input of a second subtracter (20) having its further input connected to the output of the first subtracter (17), and in that the output of the second subtracter (20) is connected to a divider (22) having its divisor input connected to a further memory (21) storing said zero gas measuring signal (V_{SO}).

3. The infrared analyzer as claimed in claim 2, **characterized in that** the memories (19, 21), the subtracters (17, 20) and the divider (21) are realized by a micro computer.

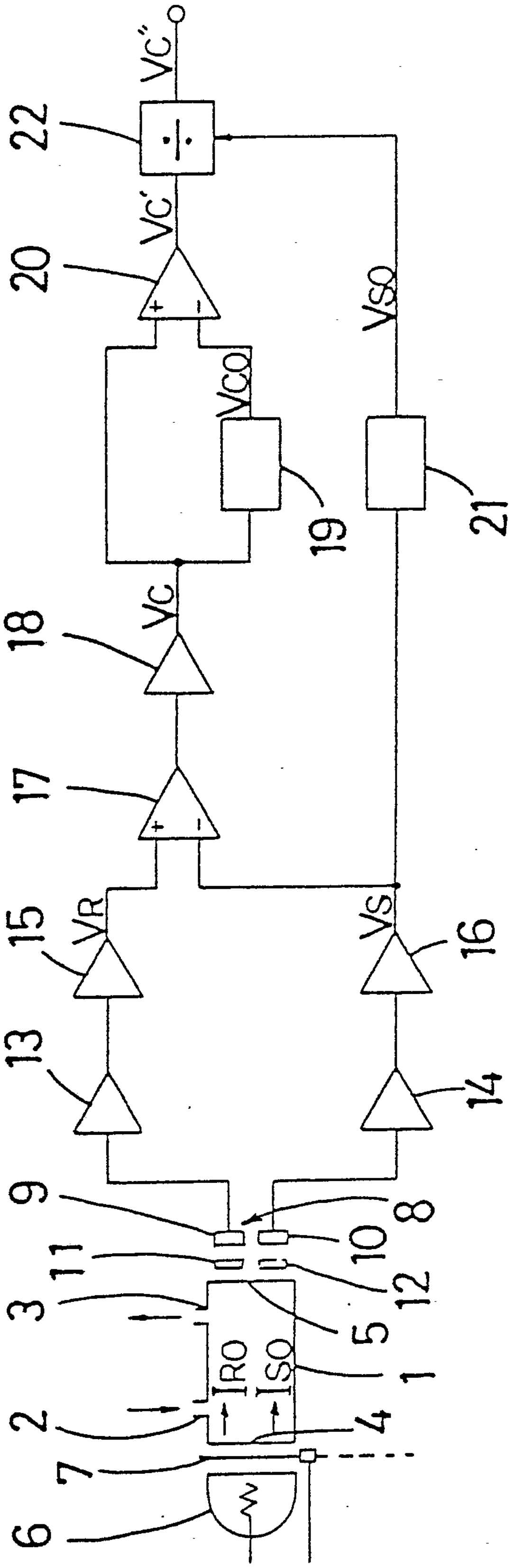

VC''
22
VC'
20
VSO
VCO
19
21
18
VC
17
15
VR
VS
16
13
14
9
8
10
11
12
3
5
IRO
ISO
1
2
4
7
6
+
-

Fig.1

Fig.2

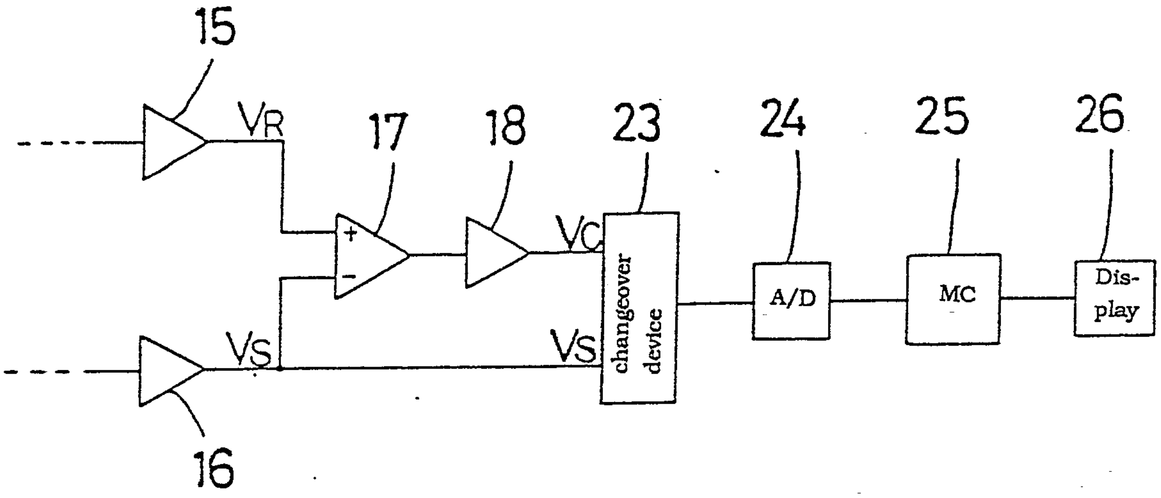
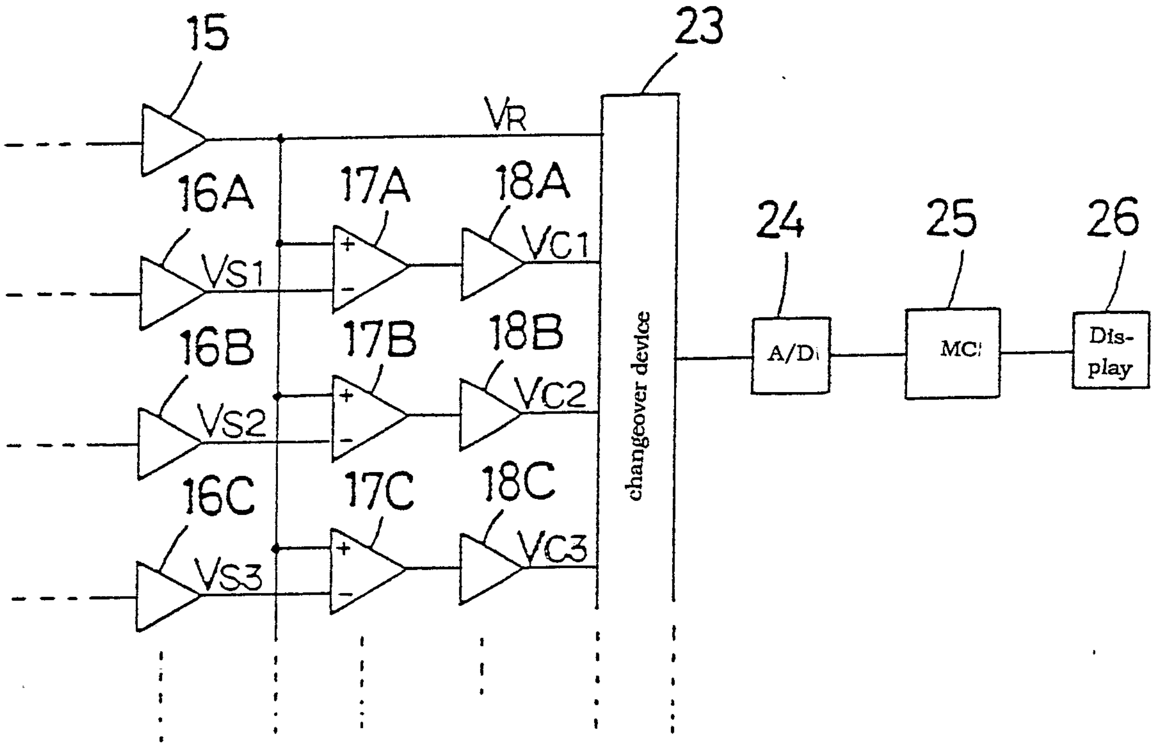

15
VR
17
18
23
24
25
26
+
−
VC
VS
VS
changeover device
A/D
MC
Dis-play
16

Fig.3


15
23
VR
16A
17A
18A
24
25
26
VS1
VC1
+
−
16B
17B
18B
VS2
VC2
A/D
MC
Dis-play
changeover device
16C
17C
18C
VS3
VC3

European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 10 8244

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-4 673 812 (A. YONEDA) * column 1, lines 5-65; figure 1 * ---	1	G 01 N 21/35
A	WO-A-8 704 240 (ANDROS ANALYZERS INC.) * abstract; figure 1 * ---	1-3	
A	EP-A-0 192 013 (DR. THIEDIG & CO.) * abstract; claim 13; figure 1 * ---	1,2	
A	EP-A-0 261 452 (HORIBA LTD.) * page 2, figure 1 * ---	1,2	
A	WO-A-8 304 097 (ANDROS ANALYZERS INC.) * abstract * ---	1	
A	MESSEN, PRUEFEN, AUTOMOTISIEREN no. 9, September 1988, pages 430-434, Bad Wörishofen, DE; G. WIEGLEB: "Infrarot-Gasanalysator Binos 100 mit integrierter Mikroprozessor-Steuerung" * page 433 * -----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G 01 N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	31-08-1990	BRISON O.P.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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